Europäisches Patentamt

European Patent Office

Office européen des brevets

Bescheinigung   Certificate   Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.	The attached documents are exact copies of the European patent application described on the following page, as originally filed.	Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

Patentanmeldung Nr.   Patent application No.   Demande de brevet n°

02256578.2

PRIORITY DOCUMENT
SUBMITTED OR TRANSMITTED IN
COMPLIANCE WITH RULE 17.1(a) OR (b)

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

R C van Dijk

Anmeldung Nr:	Anmeldetag:
Application no.: 02256578.2	Date of filing: 23.09.02
Demande no:	Date de dépôt:

Anmelder/Applicant(s)/Demandeur(s):

Telefonaktiebolaget L M Ericsson (Publ)

126 25 Stockholm
SUEDE

Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Method and apparatus for power control

In Anspruch genommene Prioriät(en) / Priority(ies) claimed /Priorité(s)
revendiquée(s)
Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/
Classification internationale des brevets:

H04B7/00

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of
filing/Etats contractants désignées lors du dépôt:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR IE IT LI LU MC NL PT SE SK TR

METHOD AND APPARATUS FOR POWER CONTROL

Technical Field of the Invention

5   The present invention relates to power control in Radio
Resource Management, and in particular to a system with
multiple transport channels.

Description of Related Art

10

In modern telecommunications networks, the utilisation of
air interface resources and the maintenance of Quality of
Service (QoS) is determined by Radio Resource Management
(RRM).   RRM is responsible for the following functions;
15   handover, power control, admission control, load control
and packet scheduling.   Each of these functions is
implemented by a relevant RRM algorithm.

Third generation telecommunications networks need to
20   support high quality services and to multiplex several
services on one connection.   In particular, power control
plays an important role in the provision of the required
QoS, by keeping the interference levels in the air
interface at a minimum.   The power control algorithm may
25   be implemented at User Equipment (UE) level, Base Station
(BS) level or Radio Network Controller (RNC) level.
These three network elements are illustrated in Figure 1,
wherein the BS 10 includes a transceiver 12 and a
processor 14, which processor 14 has a fixed connection
30   to the RNC 16.   The MS 18 is not generally of a fixed
location.

Aspects of power control which are specific to third
generation systems (such as Wideband Code Division
35   Multiple Access, WCDMA) and are not present in second
generation systems (such as Global System for Mobile

Communications, GSM) include fast power control and outer loop power control. Fast power control in WCDMA has a frequency of approximately 1.5kHz and is supported in both uplink and downlink. The outer loop power control

5 algorithm estimates the received signal quality in order to adjust the Signal to Interference Ratio (SIR) reference for the fast power control so that the required QoS is maintained. Signal quality can be affected by changes in the MS speed or the multipath propagation

10 environment. Outer loop power control in WCDMA has a frequency of approximately 10-100Hz, and is needed in both uplink and downlink because there is fast power control in both uplink and downlink.

15 Fig 2 is a flow chart outlining a general outer loop power control algorithm. An initial assessment 20 is made as to whether the quality of signal received on the uplink is better than the required quality of signal. Where this is the case, the SIR reference for fast power

20 control is decreased 22 to avoid wasted network capacity. In contrast, where the quality of signal is less than the required quality, the SIR reference is increased 24 so that the required QoS is maintained.

25 QoS is a direct function of errors arising from the received signals, which errors arise from inaccurate SIR estimation, signalling errors and delays in the power control loop. In order to assess the quality of signal received on the uplink, several known methods can be

30 employed. For example, the quality assessment can be based on an estimated physical channel Bit Error Rate (BER), received SIR or a Cyclic Redundancy Check (CRC).

The CRC assessment is generally utilised for network

35 services where errors are allowed to occur fairly frequently, at least once every few seconds. This can be

in non-real-time packet data service where the block
error rate (BLER) can be up to 10-20% before
retransmissions, and the speech service where typically
BLER = 1% provides the required quality.

5

One possible outer loop power control algorithm is given
by the so-called proportional-integral (PI) algorithm.
This can be characterised as follows:

10

$$SIR_r(k) = kp * e(k) + ki * I(k)$$

where k denotes block number, $SIR_r(k)$ denotes the SIR
reference for block k, kp and ki are parameters which
control algorithm convergence speed and stability, e(k)

15 is a variable which indicates the difference between
required QoS and actual QoS, and I(k) is a parameter
which sets a steady state value for the SIR reference,
where $I(k + 1) = I(k) + e(k)$. For example one could use;

20

$$e(k) = -BLER_r, \qquad if\ CRC\ ok,$$
$$e(k) = 1 - BLER_r, \qquad if\ CRC\ not\ ok$$

where $BLER_r$ refers to the BLER reference. It is also
possible to filter e(k) to get a smoother behaviour.
Examples of values of the constants kp and ki are kp =

25 0.3 and ki = 0.8. A special case is given by the
parameter choice:

$$kp = 0$$
$$ki = SIR_{inc} / (1 - BLER_r)$$

30 which gives the so-called jump algorithm disclosed in
"WCDMA for UMTS" edited by Holma and Toskala, Wiley &
Sons Ltd, 2000, pages 187 – 203. This jump algorithm is
based on the result of a CRC assessment of the data and
can be characterised as follows:

35

$$SIR_r(k+1) := \begin{cases} SIR_r(k) + SIR_{inc} & \text{if } CRC \, not \, OK, \\ SIR_r(k) - \dfrac{BLER_r}{1-BLER_r} SIR_{inc} & \text{if } CRC \, OK. \end{cases}$$

where SIR_{inc} refers to an incremental increase in the SIR
5   reference for the channel under consideration. SIR_{inc} is
typically 0.3dB to 1.0dB.

Both the PI algorithm and the jump algorithm calculate an
updated SIR reference value based on the value of the
10   previous SIR reference value. Where the received signal
quality is better than the required signal quality, then
the updated SIR reference value will be an incremental
decrease. Where the received signal quality is worse
than the required signal quality, then the updated SIR
15   reference value will be an incremental increase.

In order to make efficient use of network capacity, the
outer loop power control should keep the SIR reference as
low as possible at all times. Although, an SIR reference
20   value that is too low will lead to decreased QoS. The
data traffic situation can vary over time and so a
flexible and reliable system is required to ensure that
users experience an acceptable QoS.

25   This known power control function does not enable a
suitable SIR reference to be determined where multiple
transport channels are used. When multiple transport
channels are multiplexed on a physical channel a common
SIR reference must be found which gives sufficiently good
30   performance for all transport channels. The necessary
SIR level is a complicated function of coding scheme,
channel quality, equipment velocity and other parameters
and can not be calculated easily. The number of possible
combinations of transport channels is also very large
35   which makes utilisation of a look-up table unfeasible.

Summary

The present invention seeks to provide a power control
function in RRM in which the required QoS is maintained
for multiple transport channels and problems in known
systems associated with data traffic changes are
alleviated.

According to a first aspect of the present invention,
there is provided a method of power control in a mobile
telecommunications network, the method comprising the
steps of calculating a signal strength reference value
for each of a plurality of channels in use based on a
previously calculated value for that channel, maintaining
the calculated signal strength reference value for a
channel at or above a predetermined minimum signal
strength reference value, and determining a signal
strength reference value to be used for all of said
plurality of channels in use, as the highest of all of
the calculated signal strength reference values.

According to a second aspect of the present invention,
there is provided a mobile station in a
telecommunications network, wherein the mobile station
comprises means for performing power control by the
method specified in the first aspect of the present
invention.

According to a third aspect of the present invention,
there is provided a base station in a telecommunications
network, wherein the base station comprises means for
performing power control by the method specified in the
first aspect of the present invention.

According to a fourth aspect of the present invention,
there is provided a telecommunications network comprising

means for performing power control by the method
specified in the first aspect of the present invention.

It should be emphasised that the term
5 "comprises/comprising" when used in this specification is
taken to specify the presence of stated features,
integers, steps or components but does not preclude the
presence or addition of one or more other features,
integers, steps, components or groups thereof.

10

Brief Description of the Drawings

For a better understanding of the present invention, and
to show how it may be put into effect, reference will now
15 be made, by way of example, to the accompanying drawings
in which:

Figure 1 is a schematic diagram of the basic features in
a radio telecommunications network;

20

Figure 2 shows a flow chart outlining a general outer
loop power control algorithm;

Figure 3 shows a flow chart outlining use of an extended
25 outer loop power control algorithm in accordance with the
present invention; and

Figure 4 is a schematic diagram of the network structure
in accordance with the present invention.

30

Detailed Description of Embodiments

Where a telecommunications network has several channels
in use, Radio Resources Management (RRM) implements an
35 extended outer loop power control algorithm. This
algorithm functions to determine a single SIR reference

value suitable for all of the channels in use at one time. This is achieved by determining a separate used SIR reference value for each channel l, where l={1,...,number of channels in use}. The initial step may

5 be characterised as follows:

$$SIR_r(l,0)=\frac{1}{b_2}\left(\log_{10}\left(BLER_r(l)\right)-a_2\right)$$

In practice, a_2 could be 0.6 and b_2 could be -1.5.

10 Clearly, this SIR reference is dependent upon the channel user's QoS requirements.

In order to update the SIR reference for each allotted channel at the following block, k=1, a quality assessment

15 is performed on that channel (shown below using a CRC). The updating step may be characterised as follows:

$$SIR_r(l,k+1):=\begin{cases}SIR_r(l,k)+SIR_{inc} & \text{if } CRC\ (l)\ not\ OK,\\[2mm] SIR_r(l,k)-\dfrac{BLER_r(l)}{1-BLER_r(l)}SIR_{inc} & \text{if } CRC\ (l)\ OK.\end{cases}$$

where SIR_{inc} refers to an incremental increase in the SIR reference for channel l. SIR_{inc} is typically 0.3dB to

25 1.0dB, and may be the same for all channels. In other words, where the received signal quality is better than the required signal quality, then the updated SIR reference value will be an incremental decrease. Where the received signal quality is worse than the required

30 signal quality, then the updated SIR reference value will be an incremental increase.

The updated SIR reference value is compared with a predetermined minimum SIR reference value. Where the

35 former is greater than the latter, then the updated SIR reference value is used. If the updated SIR reference

value calculated is below the predetermined minimum SIR
reference value, the predetermined minimum SIR reference
value is substituted for the updated SIR reference value.
This comparison may be characterised as follows:

5

$$SIR_r(l,k+1):=\max(SIR_r(l,k+1),SIR_{min})$$

In order for the network to set an overall updated SIR
reference value for all allotted channels the following
10   equation applies:

$$SIR_r(k)=\overset{\max}{{}_l}SIR_r(l,k)$$

All channels multiplexed on a common physical channel
15   must use a common SIR reference value. Thus, the highest
updated SIR reference value for all allotted channels for
a particular block k, is used as the overall SIR
reference value for the group of channels for that block.

20   The reason for setting a predetermined minimum SIR
reference value for each channel is that, if this were
not done, the calculated SIR reference value for a
channel could reach very low values. This is the case if
the channel achieves better QoS than requested for a long
25   period of time. If the channel multiplexing situation
changes, for instance when a new channel is dropped or
added, or when the QoS parameters for a channel changes,
the used SIR reference value may become insufficient to
achieve accurate QoS for this channel. Without the
30   predetermined minimum SIR reference value, it could take
excessive time for the calculated updated SIR reference
value to reach an acceptable level again.

Typically, setting SIR_{min} to -10dB will enable all
35   allotted channels to regain control of the SIR reference

within a reasonable time (generally less than 1 second) . if the traffic situation changes.

In Figure 3, a RRM operates in step 30 to obtain an SIR
5 reference value for the initial block for the allotted channel under consideration. A QoS assessment is performed in step 32 by means of, for example, a CRC. Where it is determined that the current quality is acceptable, the SIR reference value is decremented in
10 step 34 resulting in an updated SIR reference value. However, where the QoS is inadequate for user requirements the SIR reference value is incremented in step 36 in order to achieve the updated SIR reference value. A comparison is performed in step 38 to determine
15 whether the updated SIR reference value is greater than a predetermined SIR minimum value. Thus, where the updated SIR reference value is greater than the predetermined SIR minimum value then the updated SIR reference value is utilised in step 40 for the block and channel under
20 consideration. However, where the updated SIR reference value is less than the predetermined SIR minimum value, the predetermined SIR minimum value is utilised in step 42 instead of the updated SIR reference value.

25 It will be apparent to the skilled person that the outer loop power control algorithm implemented on the channel under consideration in Figure 3 can be implemented for each of several further allotted channels within the telecommunications network under the control of the RRM.
30 The SIR reference value to be used for each channel in respect of the same block is compared in step 44 to determine a maximum used SIR reference value, which value is said to control the SIR reference value for the telecommunications network. Thus, by use of the used SIR
35 reference values of the allotted channels the RRM is

implementing an extended outer loop power control
algorithm in accordance with the present invention.

It is necessary for this process to be repeated for each
5   of blocks $k=0$, 1, 2, 3,...,n, to ensure an acceptable QoS
is provided even when the variables involved (such as
number of allotted channels, maximum SIR reference value
required, etc.) change.

10   Thus, the SIR reference value is set for multiple
transport channels and advantageously the complexity of
the extended outer loop power control algorithm is very
low.

15   Figure 4 further illustrates the flow chart of Figure 3,
showing the use of a common maximum used SIR reference
value for multiple channels within a network. A first
RMM 50, a second RMM 52 and a third RMM 54 each have two
inputs. The single output 68 70 72 from the first,
20   second and third controllers 50 52 54 are multiplexed
onto a single physical channel 76 via a single comparison
means 74.

In operation, the first RMM 50 has two input signals,
25   namely a first SIR reference value 56 and a first
predetermined SIR minimum value 58. The second RMM 52
has two input signals, a second SIR reference value 60
and a second predetermined SIR minimum value 62.
Similarly, the third RMM 54 has two input signals, a
30   third SIR reference value 64 and a third predetermined
SIR minimum value 66. Each RMM performs a QoS assessment
and, dependent upon the result, increments or decrements
the SIR reference value. Each RMM has a single output 68
70 72 comprising a used SIR value specific to that
35   channel. The comparison means 74 functions to determine
the maximum used SIR reference value from the first,

second and third used SIR values 68 70 72 input to the
comparison means 74. This value is said to control the
SIR reference value for the telecommunications network.
The QoS assessment performed by each RRM implements an
5   extended outer loop power control algorithm in accordance
with the present invention.

It will be apparent to the skilled person that the above
specified algorithm is not exhaustive and variations may
10 be employed to achieve a similar result whilst employing
the same inventive concept. For example, the extended
outer loop power control algorithm can be implemented at
a mobile station level, base station level or radio
network controller level.
15

Furthermore, the skilled person will be aware that the
present invention may be implemented in respect of any
outer loop power control algorithm, such as the PI
algorithm or the jump algorithm.
20

It can therefore be seen that the present invention
provides power control in RRM which has significant
advantages over the conventional systems.

25

30

35

CLAIMS

1.   A method of power control in a mobile
telecommunications network, the method comprising the
5   steps of:
        calculating a signal strength reference value for
each of a plurality of channels in use based on a
previously calculated value for that channel;
        maintaining the calculated signal strength reference
10   value for a channel at or above a predetermined minimum
signal strength reference value; and
        determining a signal strength reference value to be
used for all of said plurality of channels in use, as the
highest of all of the calculated signal strength
15   reference values.

2.   The method as claimed in claim 1, wherein the signal
strength reference value for a channel is a Signal-to-
Interference Ratio (SIR) reference value.
20

3.   The method as claimed in claim 1, further comprising
incrementally   increasing   or   decreasing   the   signal
strength   reference   value   dependent   upon   a   quality
criteria check.
25

4. _. The method as claimed in claims 2, wherein the step
of calculating a SIR reference value for each of the
plurality of channels in use is performed by applying the
algorithm:
30

$$SIR_r(k) = kp * e(k) + ki * I(k)$$

where k denotes block number, $SIR_r(k)$ denotes the SIR
reference for block k, kp and ki are parameters which
35   control algorithm convergence speed and stability and
I(k+1) = I(k)+e(k).

5. The method as claimed in claim 4, wherein e(k) takes different values dependent upon whether a predetermined quality criterion is met, such that:

$$e(k) = -BLER_r \qquad \text{if quality criterion met,}$$
$$e(k) = 1 - BLER_r \qquad \text{if quality criterion not met}$$

where $BLER_r$ refers to the BLER reference.

6. The method as claimed in claim 4, wherein the parameters:

$$kp = 0$$
$$ki = SIR_{inc} / (1 - BLER_r)$$

are used, where SIR_{inc} refers to an incremental increase in the SIR reference.

7. The method as claimed in claims 2, 4, 5 and 6, wherein the step of maintaining the calculated signal strength reference value for a channel is determined via a Proportional Integral (PI) algorithm and characterised by:

$$SIR_r(l, k+1) := \begin{cases} SIR_r(l,k) + SIR_{inc} & \text{if quality criterion not met} \\ SIR_r(l,k) - \dfrac{BLER_r(l)}{1 - BLER_r(l)} SIR_{inc} & \text{if quality criterion met} \end{cases}$$

where $SIR_r(l,k)$ denotes the SIR reference for channel $l=1,...,N$ at block k. $BLER_r(l)$ refers to the BLER reference for channel l.

8. The method as claimed in claim 7, wherein the quality criterion check is based on a Bit Error Rate (BER) reference value.

9.   The method as claimed in claim 7, wherein the quality criterion check is based on a Cyclic Redundancy Check (CRC) reference value.

5

10.   The method as claimed in claim 7, comprising calculating an initial SIR reference value $SIR_r(1, 0)$ for each of the plurality of channels in use for an initial block $k=0$ as:

10

$$SIR_r(l,0)=\frac{1}{b_2}\left(\log_{10}\left(BLER_r(l)\right)-a_2\right)$$

where a_2 and b_2 are channel model parameters.

15   11.   The method as claimed in claims 1 to 10, wherein the mobile telecommunications network uses WCDMA.

12.   A mobile station for use in a telecommunications network, wherein the mobile station comprises means for
20   performing power control by a method comprising:
        calculating a signal strength reference value for each of a plurality of channels in use based on a previously calculated value for that channel;
        maintaining the calculated signal strength reference
25   value for a channel at or above a predetermined minimum signal strength reference value; and
        determining a signal strength reference value to be used for all of said plurality of channels in use, as the highest of all of the calculated signal strength
30   reference values.

13.   The mobile station as claimed in claim 12, wherein the step of maintaining the calculated signal strength reference value for a channel is determined via a
35   Proportional Integral (PI) algorithm and characterised by:

$$SIR_r(l,k+1):=\begin{cases} SIR_r(l,k)+SIR_{inc} & \text{if quality criterion } no\\ SIR_r(l,k)-\dfrac{BLER_r(l)}{1-BLER_r(l)}SIR_{inc} & \text{if quality criterion } m \end{cases}$$

where $SIR_r(l,k)$ denotes the SIR reference for channel $l=1,...,N$ at block k. $BLER_r(l)$ refers to the BLER reference for channel l.

14. The mobile station as claimed in claims 12 and 13, wherein the mobile telecommunications network uses WCDMA.

15. A base station for use in a telecommunications network, wherein the base station comprises means for performing power control by a method comprising:

calculating a signal strength reference value for each of a plurality of channels in use based on a previously calculated value for that channel;

maintaining the calculated signal strength reference value for a channel at or above a predetermined minimum signal strength reference value; and

determining a signal strength reference value to be used for all of said plurality of channels in use, as the highest of all of the calculated signal strength reference values.

16. The base station as claimed in claim 15, wherein the step of maintaining the calculated signal strength reference value for a channel is determined via a Proportional Integral (PI) algorithm and characterised by:

$$SIR_r(l,k+1):=\begin{cases} SIR_r(l,k)+SIR_{inc} & \text{if quality criterion } not\\ SIR_r(l,k)-\dfrac{BLER_r(l)}{1-BLER_r(l)}SIR_{inc} & \text{if quality criterion } met \end{cases}$$

where SIR_r $(1,k)$ denotes the SIR reference for channel $1=1,...,N$ at block k. $BLER_r(1)$ refers to the BLER reference for channel 1.

5

17. The base station as claimed in claims 15 and 16, wherein the mobile telecommunications network uses WCDMA.

18. A telecommunications network, comprising means for
10 performing power control by a method comprising:
    calculating a signal strength reference value for each of a plurality of channels in use based on a previously calculated value for that channel;
    maintaining the calculated signal strength reference
15 value for a channel at or above a predetermined minimum signal strength reference value; and
    determining a signal strength reference value to be used for all of said plurality of channels in use, as the highest of all of the calculated signal strength
20 reference values.

19. The telecommunications network as claimed in claim 18, wherein the step of maintaining the calculated signal strength reference value for a channel is determined via
25 a Proportional Integral (PI) algorithm and characterised by:

$$SIR_r(l,k+1) := \begin{cases} SIR_r(l,k) + SIR_{inc} & \textit{if quality criterion not } \textit{t} \\ SIR_r(l,k) - \dfrac{BLER_r(l)}{1-BLER_r(l)} SIR_{inc} & \textit{if quality criterion met} \end{cases}$$

30

where SIR_r $(1,k)$ denotes the SIR reference for channel $1=1,...,N$ at block k. $BLER_r(1)$ refers to the BLER reference for channel 1.

35

20.   The telecommunications network as claimed in claims
18 and 19, wherein the mobile telecommunications network
uses WCDMA.

5

10

15

20

25

30

35

Method and Apparatus for Power Control

Abstract

5   A telecommunications system for improving quality of
    service (QoS) to users via the implementation of an
    extended outer loop power control algorithm. A radio
    resource manager (RRM) operates to determine the number
    of channels allotted to users within a network at a
10 certain time. The RRM implements the extended outer loop
    power control algorithm for each allotted channel, thus
    determining SIR reference values for each allotted
    channel. The RRM ensures that the SIR reference value
    for any channel does not fall below a predetermined
15 minimum value. The SIR reference value to be used for
    all channels in use is determined as the highest of all
    the calculated SIR reference values. The extended outer
    loop power control algorithm can be implemented at a
    mobile station level, base station level or radio network
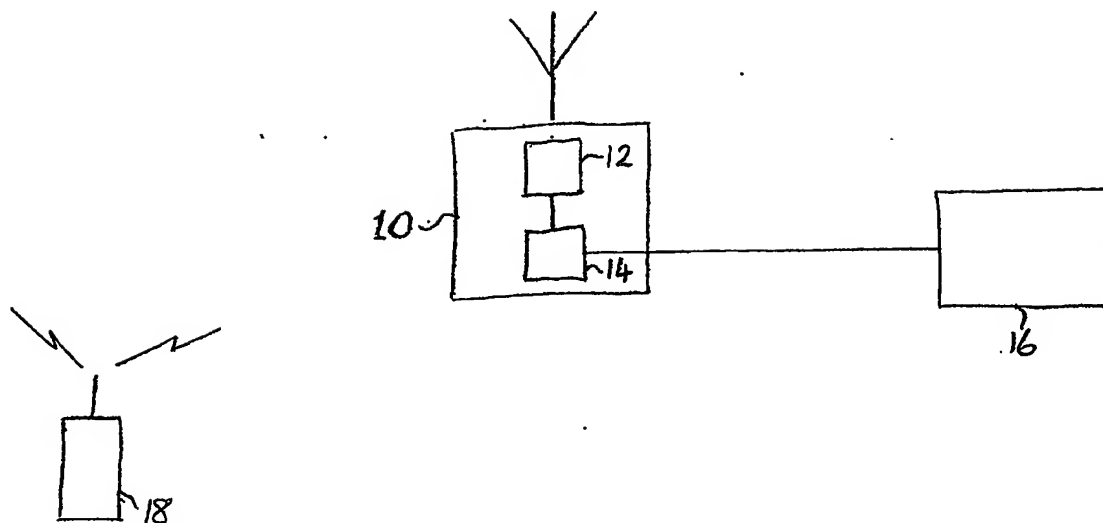20 controller level.

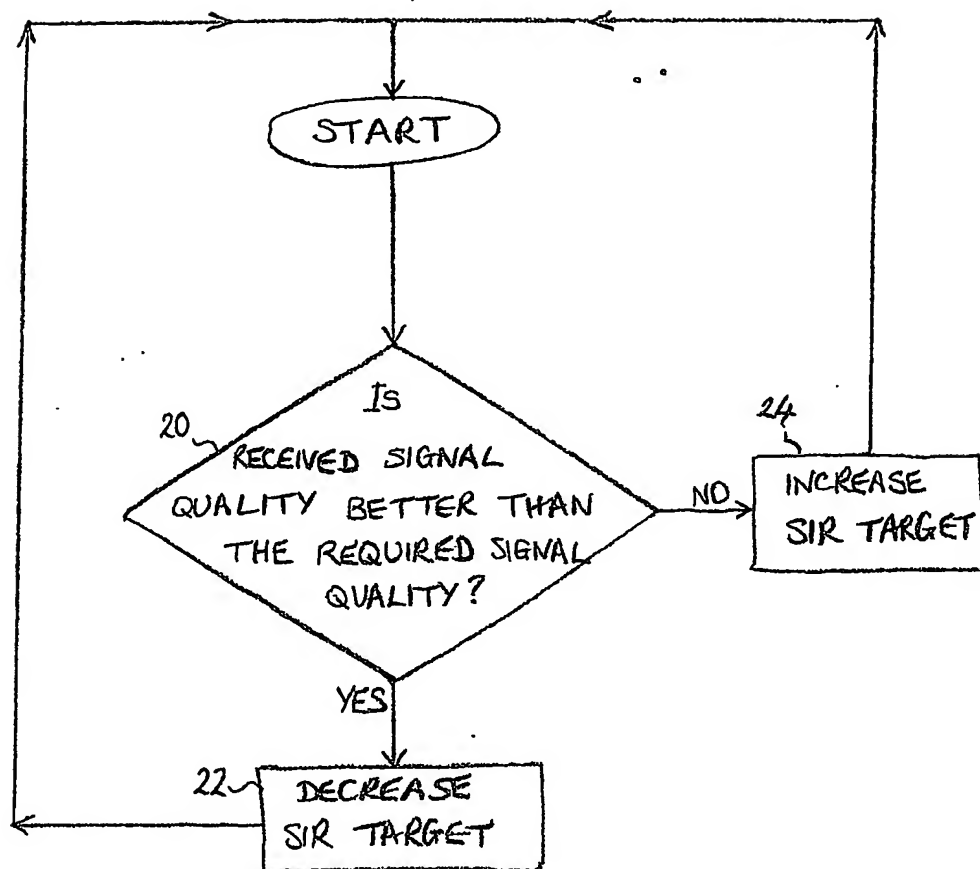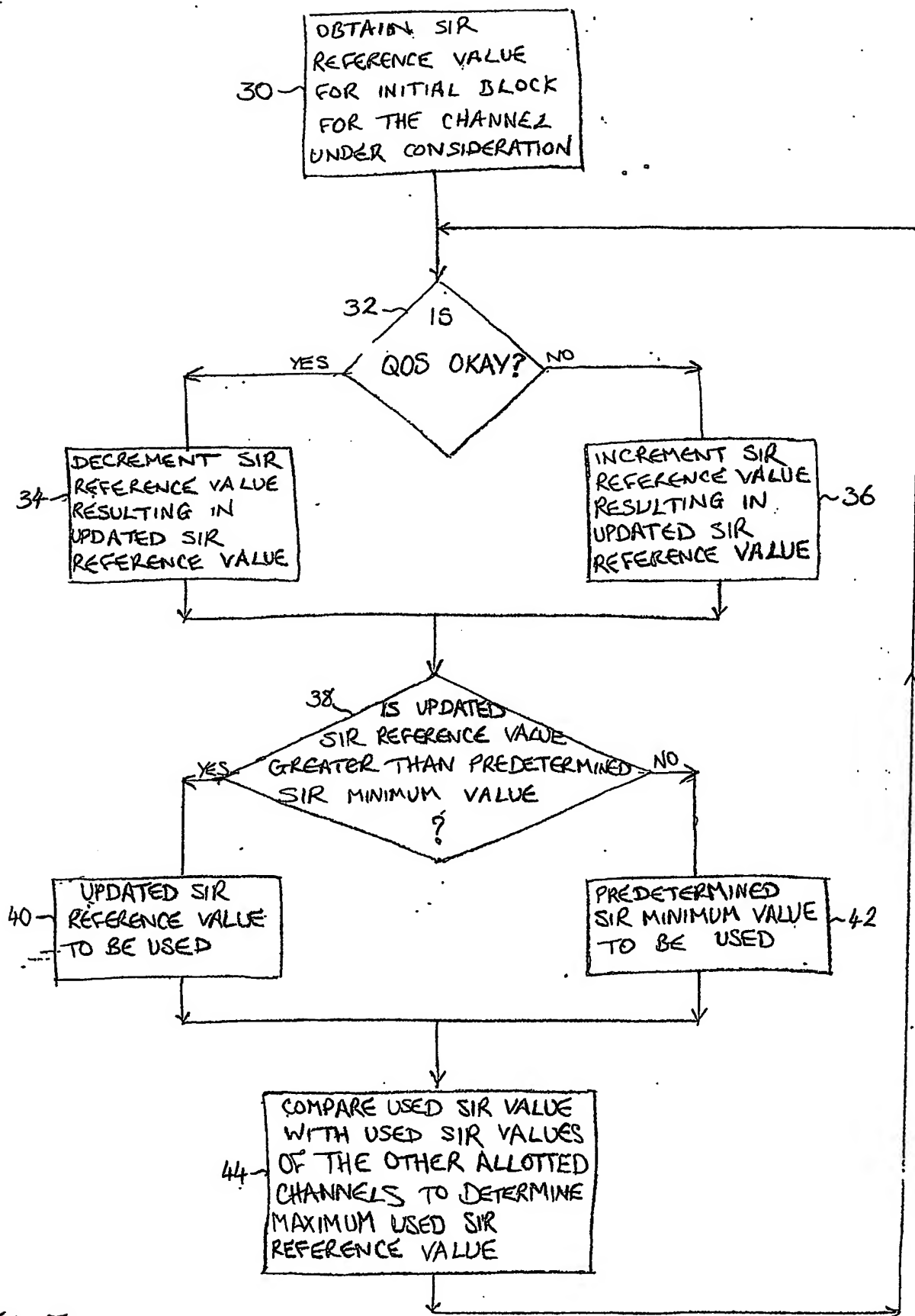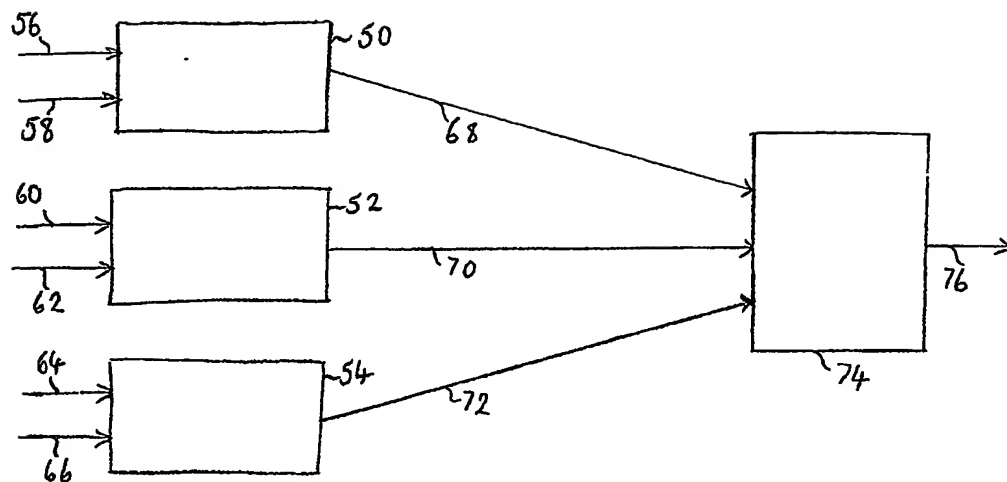   [Figure 1]

25

30

35

FIG. 1

FIG. 2.

OBTAIN SIR
REFERENCE VALUE
30 — FOR INITIAL BLOCK
FOR THE CHANNEL
UNDER CONSIDERATION

32 — IS
QOS OKAY?
YES   NO

DECREMENT SIR
REFERENCE VALUE
34 — RESULTING IN
UPDATED SIR
REFERENCE VALUE

INCREMENT SIR
REFERENCE VALUE
RESULTING IN   ~36
UPDATED SIR
REFERENCE VALUE

38 — IS UPDATED
SIR REFERENCE VALUE
GREATER THAN PREDETERMINED
SIR MINIMUM VALUE
?
YES   NO

UPDATED SIR
40 — REFERENCE VALUE
TO BE USED

PREDETERMINED
SIR MINIMUM VALUE   ~42
TO BE USED

COMPARE USED SIR VALUE
WITH USED SIR VALUES
44 — OF THE OTHER ALLOTTED
CHANNELS TO DETERMINE
MAXIMUM USED SIR
REFERENCE VALUE

FIG. 3

FIG. 4